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Effects of Government Intervention with a Differentiated Oligopolistic Food Sector

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Abstract

This paper considers the effects of government policies when processed food markets are imperfectly competitive. Importantly, the effects differ between Bertrand and Cournot competition. In particular, although there is incomplete policy transmission to food prices, it is greater if firms follow Bertrand rather than Cournot strategies when products are differentiated.

Introduction

In recent years, agricultural economists have increasingly focussed on the processing and distributive industries as an important constituent of the food sector in developed economies. This research indicates that these industries tend to be characterized, to varying degrees, by oligopolistic market structures, (see for example, Burns *et al*, 1983, and Connor *et al*, 1985). However, this research has tended to treat these activities in an isolated manner, paying only slight attention to any interdependence between horizontal market competition and vertical market links. Also, work focussing on the farm-retail spread and how it may be affected policy, has assumed competitive markets, thus ignoring a key characteristic of the food industries (see for example, Gardner, 1975, and Chambers, 1983).

The aim of this paper, therefore, is to consider the effects on the food processing sector of farm support policies and trade policies that impact on food prices, taking account of imperfect competition in food processing. The key proposition of the paper is that the effect on food prices of a change in government support, whether domestic or against foreign competitors, will depend on the nature of strategic interaction in the processing industries, i.e. Cournot versus Bertrand strategies, and the extent of food product differentiation. In other words, the effect of vertical linkages between different parts of the food chain depends in part on the nature of horizontal strategic interaction. It is also shown that the effect of government policies on firms' market shares and revenues will differ between Cournot and Bertrand behavior.

The paper is organized as follows: Section 1 outlines the model; the comparative static effects on market shares, revenues and food prices following a change in government support are considered in Section 2 and Section 3 draws some conclusions.

1. Theoretical Framework

It is assumed that the relevant processed food market is dominated by two firms, one domestic and one foreign. Unprocessed agricultural produce enters the firms' cost functions, this produce being derived from their respective domestic agricultural sectors. These firms compete with other firms for the farm produce, the latter serving different and segmented markets, hence there are no spillover effects from other processed food sectors and the issue of monopsony does not arise with respect to the farming sector[1]. Both firms have constant cost schedules. In this framework, government policy can take either of two forms: domestic agricultural policy aimed at giving farmers higher prices which affects the home firm's costs (c_1); restrictions on imports of the processed good, which affects the foreign firm's costs (c_2)[2]. Other sectors of the economy can be regarded as a competitive *numeraire* so that the consumer's utility function is linear and separable in the *numeraire*. Thus income effects can be ignored and partial equilibrium analysis can be conducted.

The representative consumer maximizes:

(1) $$U(q_1,q_2) - \sum_{i=1}^{2} p_i q_i$$

where q_i and p_i are the amount and price of each good and $U(q_1,q_2)$ is given by:

(2) $$U(q_1,q_2) = a_1 q_1 + a_2 q_2 - (b_1 q_1^2 + b_2 q_2^2 + 2k q_1 q_2)/2$$

where (2) is quadratic and concave, a_i and b_i are assumed positive, and subscript 1 (2) refers to the domestic (foreign) good. Maximizing expression (1) generates the following inverse demand functions:

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[1] In order to avoid the problem of bilateral oligopoly, the distributive sector is assumed to be competitive.

[2] Trade policies can also be thought of as foreign farm support policies insofar as they have a similar effect.

(3) $$p_1 = a_1 - b_1 q_1 - k q_2$$

(4) $$p_2 = a_2 - b_2 q_2 - k q_1$$

where $b_1b_2 - k^2 > 0$ if the products are imperfect substitutes, $b_1b_2 - k^2 = 0$ if they are perfectly substitutable and $k = 0$ if they are independent.

The direct demand functions can be written as:

(5) $$q_1 = \alpha_1 - \beta_1 p_1 + \gamma p_2$$

(6) $$q_2 = \alpha_2 - \beta_2 p_2 + \gamma p_1$$

where the parameters are defined as follows:

(7) $$\alpha_1 = \frac{a_1 b_2 - k a_2}{b_1 b_2 - k^2} \quad ; \quad \alpha_2 = \frac{a_2 b_1 - k a_1}{b_1 b_2 - k^2}$$
$$\beta_1 = \frac{b_2}{b_1 b_2 - k^2} \quad ; \quad \beta_2 = \frac{b_1}{b_1 b_2 - k^2} \quad ; \quad \gamma = \frac{k}{b_1 b_2 - k^2}$$

As above, if $\beta_1\beta_2 - \gamma^2 > 0$, products are imperfectly substitutable, $\beta_1\beta_2 - \gamma^2 = 0$ if they are perfectly substitutable and $\gamma = 0$ if they are independent.

Since the focus of this paper is on analyzing the outcome of government policies when firms play either Cournot (quantity-setting) or Bertrand strategies (price-setting), it is necessary to establish the initial Nash equilibria.

(a) Cournot Equilibrium

In a Cournot game, each processing firm chooses quantity in order to maximize profits, assuming the output of its competitor is given. Focussing on the domestic firm (firm 1), it maximizes profits π_1 as given by:

(8) $$\pi_1 = q_1(a_1 - b_1 q_1 - k q_2) - c_1 q_1$$

(9)
$$\frac{d\pi_1}{dq_1} = a_1 - 2b_1q_1 - kq_2 - c_1 = 0$$

and thus:

(10)
$$q_1 = \frac{a_1 - kq_2 - c_1}{2b_1}$$

where (10) is firm 1's reaction function, which is downward-sloping with slope of $-k/2b_1$. Similarly, the foreign firm's (firm 2) reaction function is given as:

(11)
$$q_2 = \frac{a_2 - kq_1 - c_2}{2b_2}$$

which is also downward-sloping with slope of $-k/2b_2$. Assuming the usual stability conditions for these functions (see Tirole, 1989), there will be a Cournot-Nash equilibrium in quantities, the explicit expressions being:

(12)
$$q_1^C = \frac{2b_2(a_1 - c_1) - k(a_2 - c_2)}{4b_1b_2 - k^2}$$

(13)
$$q_2^C = \frac{2b_1(a_2 - c_2) - k(a_1 - c_1)}{4b_1b_2 - k^2}$$

the Cournot equilibrium prices are:

(14)
$$p_1^C = a_1 - \frac{(2b_1b_2 - k^2)(a_1 - c_1) - b_1k(a_2 - c_2)}{4b_1b_2 - k^2}$$

(15)
$$p_2^C = a_2 - \frac{(2b_1b_2 - k^2)(a_2 - c_2) - b_2k(a_1 - c_1)}{4b_1b_2 - k^2}$$

(b) Bertrand Equilibrium

In a Bertrand game, each firm chooses price to maximize profits assuming the price of its rival is given. Again, focussing on the domestic firm, it maximizes π_1 as given by:

(16) $$\pi_1 = p_1(\alpha_1 - \beta_1 p_1 + \gamma p_2) - c_1(\alpha_1 - \beta_1 p_1 + \gamma p_2)$$

(17) $$\frac{d\pi_1}{dp_1} = \alpha_1 - 2\beta_1 p_1 + \gamma p_2 + c_1\beta_1 = 0$$

and thus:

(18) $$p_1 = \frac{\alpha_1 + \gamma p_2 + c_1\beta_1}{2\beta_1}$$

This is firm 1's reaction function in price which is upward-sloping with slope of $\gamma/2\beta_1$. Similarly for firm 2:

(19) $$p_2 = \frac{\alpha_2 + \gamma p_1 + c_2\beta_2}{2\beta_2}$$

which is also upward-sloping with slope of $\gamma/2\beta_2$. Assuming stability of the reaction functions, the explicit Bertrand-Nash price and quantity equilibria can be written as:

(20) $$p_1^B = \frac{2\beta_2(\alpha_1 + c_1\beta_1) + \gamma\alpha_2 + c_2\beta_2\gamma}{4\beta_1\beta_2 - \gamma^2}$$

(21) $$p_2^B = \frac{2\beta_1(\alpha_1 + c_2\beta_2) + \gamma\alpha_1 + c_1\beta_1\gamma}{4\beta_1\beta_2 - \gamma^2}$$

(22) $$q_1^B = \alpha_1 + \frac{2\beta_1[\gamma(\alpha_2 + \beta_2 c_2) - \beta_2(\alpha_1 + c_1\beta_1)]}{4\beta_1\beta_2 - \gamma^2} + \frac{\gamma^2(\alpha_1 + c_1\beta_1) - \gamma(\beta_1\alpha_2 + \beta_1 c_2\beta_2)}{4\beta_1\beta_2 - \gamma^2}$$

(23) $$q_2^B + \alpha_2 + \frac{2\beta_2[\gamma(\alpha_1 + \beta_1 c_1) - \beta_1(\alpha_2 + c_2\beta_2)]}{4\beta_1\beta_2 - \gamma^2} + \frac{\gamma^2(\alpha_2 + c_2\beta_2) - \gamma(\alpha_1\beta_2 + \beta_2 c_1\beta_1)}{4\beta_1\beta_2 - \gamma^2}$$

As shown by Singh and Vives (1984) and Cheng (1985), Cournot equilibrium quantities (prices) will be lower (higher) than Bertrand equilibrium quantities (prices). Firms' profits are also greater under Cournot compared to Bertrand. The remainder of this paper is concerned with the effects of relative changes in prices and quantities following changes in government intervention given, firms pursue either Cournot or Bertrand strategies.

2. The Effects of Government Intervention

(a) Domestic Agricultural Policy

It is assumed that governments use price support policies as the main instrument in the agricultural sector. Since farm produce enters the cost function of the domestic firm, this policy will influence the competitiveness of the domestic processing firm when competing with the foreign firm. The effect on market share, processed food prices and firms' revenues are now outlined.

Focussing first on the Cournot case, the effect of increasing c_1 on firm 1 and 2's output is seen by differentiating (12) and (13) with respect to c_1:

$$\frac{dq_1^C}{dc_1} = \frac{-2b_2}{4b_1b_2 - k^2} \tag{24}$$

$$\frac{dq_2^C}{dc_1} = \frac{k}{4b_1b_2 - k^2} \tag{25}$$

Clearly, following an increase in domestic agricultural support, the domestic firm loses market share, while the foreign firm increases its share of the market.

The effect on prices is obtained by differentiating (14) and (15) with respect to c_1:

$$\frac{dp_1^C}{dc_1} = \frac{2b_1b_2 - k^2}{4b_1b_2 - k^2} = \frac{1}{2} \tag{26}$$

$$\frac{dp_2^C}{dc_1} = \frac{b_2k}{4b_1b_2 - k^2} < 1 \tag{27}$$

Both domestic and foreign firms' prices rise, which suggests that the cut-back in the domestic firm's output is not offset by an increase in that of the foreign firm. This is as expected given the stability conditions for the reaction functions. Importantly, policy price increases are not fully transmitted to increased food prices. Expression (26), indicates that the domestic firm only passes on half of the cost increase to consumers The outcome is less clear for the foreign firm, although the cost increase is passed on less than fully (it will be less than a half if either b_2 or k is less than a half). The intuition for this result is the competitive discipline of the foreign firm on the domestic firm as the former moves down its reaction function, given the cut-back in output by the latter.

The change in revenue for the domestic and foreign firms is given by:

(28) $$\frac{dR_1^C}{dc_1} = \frac{-b_2}{4b_1b_2 - k^2}$$

(29) $$\frac{dR_2^C}{dc_1} = \frac{b_2k}{(4b_1b_2 - k^2)^2}$$

which follows from (24)-(27). Clearly, revenues decline (increase) for the domestic (foreign) processing firm.

A similar exercise in comparative statics can be carried out for the case of Bertrand behavior. The effect on market share of an increase in domestic farm support is given by differentiating (22) and (23) with respect to c_1:

(30) $$\frac{dq_1^B}{dc_1} = \frac{-2\beta_1^2\beta_2 + \gamma^2\beta_1}{4\beta_1\beta_2 - \gamma^2}$$

(31) $$\frac{dq_2^B}{dc_1} = \frac{\beta_1\beta_2\gamma}{4\beta_1\beta_2 - \gamma^2}$$

As in the case of Cournot, the home firm's output and hence market share declines while that of the foreign firm increases.

The change in processed food prices is given by differentiating (20) and (21) with respect to c_1:

(32) $$\frac{dp_1^B}{dc_1} = \frac{\beta_2 \beta_1}{2\beta_1 \beta_2 - \gamma^2}$$

(33) $$\frac{dp_2^B}{dc_1} = \frac{\gamma \beta_1}{4\beta_1 \beta_2 - \gamma^2}$$

Both prices increase, the increase in p_1^B being greater than p_2^B if the goods are imperfect substitutes. Again, policy price transmission is less than complete, though pass-through is greater the more substitutable the products. Finally, with respect to firms' revenue:

(34) $$\frac{dR_1^B}{dc_1} = \frac{-\beta_1^2 \beta_2}{4\beta_1 \beta_2 - \gamma^2}$$

(35) $$\frac{dR_2^B}{dc_1} = \frac{\beta_2 \beta_1^2 \gamma^2}{(4\beta_1 \beta_2 - \gamma^2)^2}$$

which follows from (30)-(33). The domestic firm's revenue falls and that of the foreign firm increases.

From the above analysis, the Cournot and Bertrand outcomes can be compared.

Proposition 1: Following an increase in domestic farm support, *(a)* for sufficiently low values of the demand parameters, the domestic firm will lose a bigger share of the market if playing Cournot compared to Bertrand, *(b)* for sufficiently low values of the demand parameters, the foreign firm's increased share of the market will be relatively smaller under Bertrand than Cournot strategies, *(c)* if products are imperfect substitutes, domestic price transmission is greater under Bertrand than Cournot, *(d)* there is no difference in changes in the foreign firm's prices with the two alternative strategies and *(e)* the loss in home firm's revenue is lower under Bertrand than Cournot and, for sufficiently low values of the demand parameters, the revenue gain for the foreign firm is less under Bertrand than Cournot.

Proof: Proposition 1(a) can be shown by substituting (7) into (30) and comparing with (24):

$$\left.\frac{dq_1^B}{dq_1^C}\right|_{dc_1} = \frac{2b_1b_2 + k^2}{2} \tag{36}$$

which will be less than 1 if b_1 and b_2 are sufficiently small, if not, the result is reversed.

Proposition 1(b) is illustrated by substituting (7) into (31) and comparing with (25):

$$\left.\frac{dq_2^B}{dq_2^C}\right|_{dc_1} = b_1b_2 \tag{37}$$

which is less than 1 for sufficiently low values of b_1 and b_2. If this does not hold, the result is reversed.

Proposition 1(c) is shown by substituting (7) into (32) and comparing with (26):

$$\left.\frac{dp_1^B}{dp_1^C}\right|_{dc_1} = \frac{b_1b_2}{b_1b_2 - k^2} \tag{38}$$

Hence, if the processed foods are imperfect substitutes, policy price transmission is greater with Bertrand than Cournot strategies.

Proposition 1(d) is proved by substituting (7) into (33) and comparing with (27):

$$\left.\frac{dp_2^B}{dp_2^C}\right|_{dc_1} = 1 \tag{39}$$

Finally, *Proposition 1(e)* is established by comparing (34) and (35) following, the appropriate substitution from (7) and comparing with (28) and (29) respectively:

$$\left.\frac{dR_1^B}{dR_1^C}\right|_{dc_1} = b_1b_2 \tag{40}$$

$$(41) \qquad \left.\frac{dR_2^B}{dR_2^C}\right|_{dc_1} = b_1 b_2 k$$

(40) will be less than 1, with b_1 and/or b_2 less than 1, suggesting that the loss in revenue for the domestic firm is lower for Bertrand than Cournot behavior, while for the foreign firm, (41) suggests that the revenue gain for the foreign firm will be less under Bertrand than Cournot behavior.

(b) Trade Policy

This section considers the effects of tariffs imposed on imports of the processed food, there being no trade in raw agricultural produce. An alternative way of interpreting the following results is to consider the effects of the foreign government raising its domestic farm support price. Given the nature of the model, the results presented are largely symmetric to those already reported, hence for convenience, only the final results are presented.

Proposition 2: If the government imposes a tariff on imports of processed food, *(a)* for sufficiently high values of the inverse demand parameters, the increase in market share for the home firm is greater under Bertrand than Cournot, *(b)* for sufficiently high values of the inverse demand parameters, the loss in market share for the foreign firm is greater under Bertrand than Cournot, *(c)* there is no difference between the Bertrand and Cournot strategies with respect to the effect on domestic food prices, *(d)* if products are differentiated, the transmission of tariffs to final prices is greater under Bertrand than Cournot and *(e)* for sufficiently high values of b_1 and/or b_2, the home (foreign) firm's revenue gain (loss) is greater under Bertrand than Cournot.

Proof: By differentiating the relevant expressions for prices and quantities with respect to

c_2, substituting in from (7) and comparing the Cournot and Bertrand cases;

Proposition 2(a):

(42) $$\left.\frac{dq_1^B}{dq_1^C}\right|_{dc_2} = b_1(2b_2 - 1)$$

For sufficiently high values of b_1 and b_2, (42) will be greater than 1.

Proposition 2(b):

(43) $$\left.\frac{dq_2^B}{dq_2^C}\right|_{dc_2} = \frac{2b_1b_2 - k^2}{2}$$

which will be greater than 1 for sufficiently high values of b_1 and b_2.

Proposition 2(c):

(44) $$\left.\frac{dp_1^B}{dp_1^C}\right|_{dc_2} = 1$$

i.e. the effects of tariffs on prices are the same for Cournot and Bertrand strategies.

Proposition 2(d):

(45) $$\left.\frac{dp_2^B}{dp_2^C}\right|_{dc_2} = \frac{b_1b_2}{b_1b_2 - k^2}$$

For differentiated products, policy price transmission is greater under Bertrand than Cournot.

Proposition 2(e): is determined from the results for prices and quantities:

(46) $$\left.\frac{dR_1^B}{dR_1^C}\right|_{dc_2} = b_1(2b_2 - 1)$$

(47) $$\left.\frac{dR_2^B}{dR_2^C}\right|_{dc_2} = \frac{2b_1b_2(2b_1b_2 - k^2)}{4b_1b_2 - k^2}$$

3. Summary and Conclusions

This paper has considered the effect of government policies that either directly affect the domestic farm sector or affect the flow of processed food imports to the domestic market, explicitly accounting for strategic interaction between domestic and foreign processing firms. It has been shown that government policy has different effects on firms' market shares and revenues and food prices depending on whether firms play Cournot or Bertrand. The structure of the market has also been shown to be important insofar as it is reflected in the parameters of the demand system and the extent of product differentiation. A key result of the paper is that policy price transmission is incomplete in both the Bertrand and Cournot cases, though it is likely to be greater in the former than the latter. The intuition for such incomplete transmission is that the policy acts as a restraint on the firm directly affected, given the firms are acting non-cooperatively.

Some cautionary remarks should be made at this point. Following the maxim that results from oligopoly theory can be solely a function of the initial assumptions (Bulow *et al*, 1985), it is worth noting that the results reported here may be specific to the linearity of the demand system. That being so, such comparative statics exercises ought to be conducted with alternative functional forms, the advantage of linearity being simplicity. Further, only two forms of strategic interaction have been considered; other forms of oligopolistic behavior as well as more specific policy actions (e.g. deficiency payments, quotas etc.) are also worthy of consideration in future research.

References

Bulow, J.I., Geankoplos, J.D. and Klemperer, P.D. (1985) "Multimarket Oligopoly: Strategic Substitutes and Complements", Journal of Political Economy, 93, 488-511.

Burns, J., McInerney, J. and Swinbank, A. (1983) The Food Industry: Economics and Policies, Heinemann: London.

Chambers, R.G. (1983) "International Trade, Gross Substitutability and the Domestic Farm-Retail Margin", European Review of Agricultural Economics, 10, 33-53.

Cheng, L. (1985) "Comparing Bertrand and Cournot Equilibria: A Geometric Approach", Rand Journal of Economics, 16, 146-152.

Connor, J.M., Rogers, R.T., Marion, B.W., Mueller, W.F. (1985) The Food Manufacturing Industries, Lexington: Mass.

Gardner, B.L. (1975) "The Farm-Retail Price Spread in a Competitive Food Industry", American Journal of Agricultural Economics, 57, 399-409.

Singh, N. and Vives, X. (1984) "Price and Quantity Competition in a Differentiated Duopoly", Rand Journal of Economics, 15, 546-551.

Tirole, J. The Theory of Industrial Organization, MIT Press: Mass.